

# G.A.Kirby

## Content of Presentation

- Low temperature data for magnet-materials (Cu, NbTi, Insulation)  
Specific heat, thermal conductivity, resistivity .....
- 4.5K Thermosyphon and 1.9K conduction
- HEPAC Old DOs program calculates:  
helium properties at different temp and pressures
- [\\Srv2\\_div\cryo\TOOLS\CRYODATA\HEPAK3.4](\\Srv2_div\cryo\TOOLS\CRYODATA\HEPAK3.4)
- Computational Fluid Dynamics.  
<https://edms.cern.ch/document/624664/1> .
  - MQY study. Heat Conduction through coil with a simple annular heating. (study completed)
  - MQY study. Convection of helium through MQY structure.  
(study in progress)

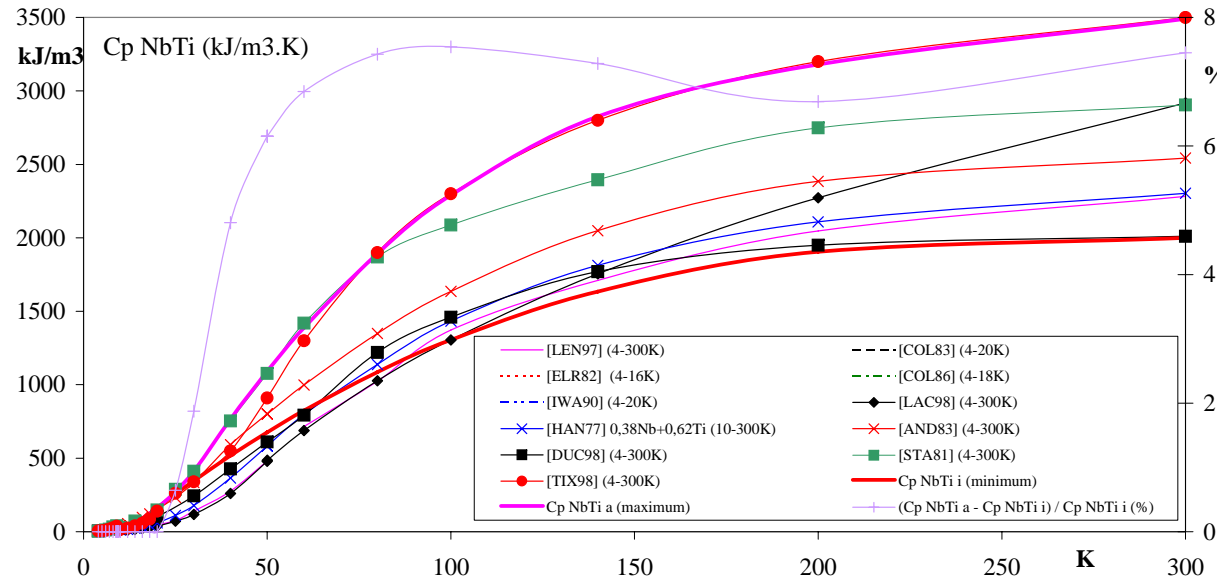
# \*\* Hunt for data \*\*

## Materials

NbTi  
Copper  
Kapton  
Epoxy  
Stainless Steel  
Iron

## Cryogenic Material Properties

Cp  
Resistivity  
Conductivity  
.....



	Cp NbTi (B,T) in J/m <sup>3</sup> .K
T < 20 K	$T_{cB} = 9.2 * (1 - B / 14.5) ^{0.59}$ If $T < T_{cB}$ Then $C_p = 49.1 * T ^ 3 + 64 * B * T$ Else $C_p = 16.4 * T ^ 3 + 928 * T$
T < 50 K	$C_p = -0.217724 * T ^ 4 + 11.983792 * T ^ 3 + 553.712993 * T ^ 2 - 7846.120813 * T + 41382.928569$
T < 175 K	$C_p = [-0.00000000482 * T ^ 4 + 0.00000297583 * T ^ 3 - 0.00071625148 * T ^ 2 + 0.08302230116 * T - 1.53178 ] * 10^6$
T < 500 K	$C_p = [-0.000000000629 * T ^ 4 + 0.000000929657 * T ^ 3 - 0.0000516653121 * T ^ 2 + 0.0137062419692 * T + 1.23554 ] * 10^6$
T < 1000 K	$C_p = [-0.000000257 * T ^ 2 + 0.000955466 * T + 2.450087571 ] * 10^6$

# 4.5K thermosyphon and 1.9K conduction

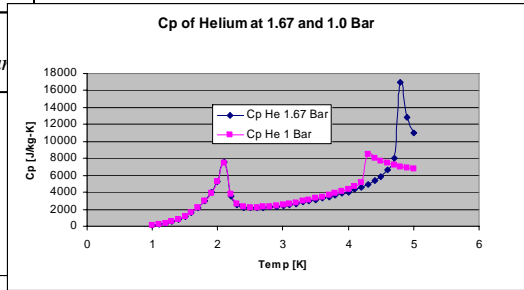
$$Q = \dot{M} \cdot C_p \cdot \Delta T_{Helium}$$

$$\dot{M} = \frac{Q}{C_p \cdot \Delta T_{Helium}}$$

$$Buoyancy = V \cdot (\rho_{4.8K} - \rho_{4.5K}) \cdot g$$

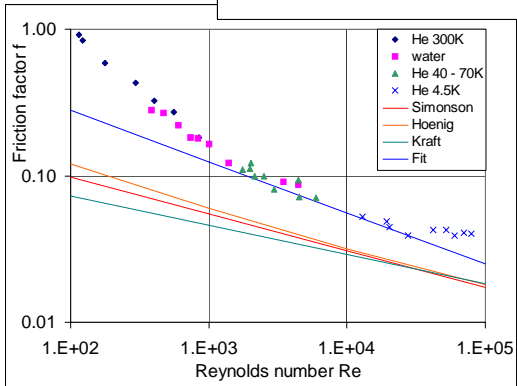
$$P = \frac{2f}{D_h \rho} \left( \frac{M}{A_h} \right)^2$$

$$\dot{M} = A_h \sqrt{\frac{P D_h \rho}{2f}}$$



$$Re = \frac{M}{A_h} \frac{D_h}{\mu}$$

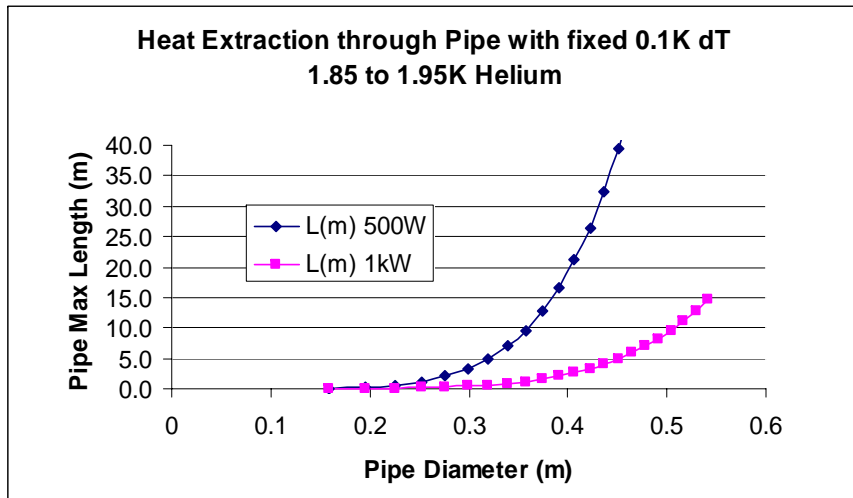
>10<sup>5</sup> its turbulent



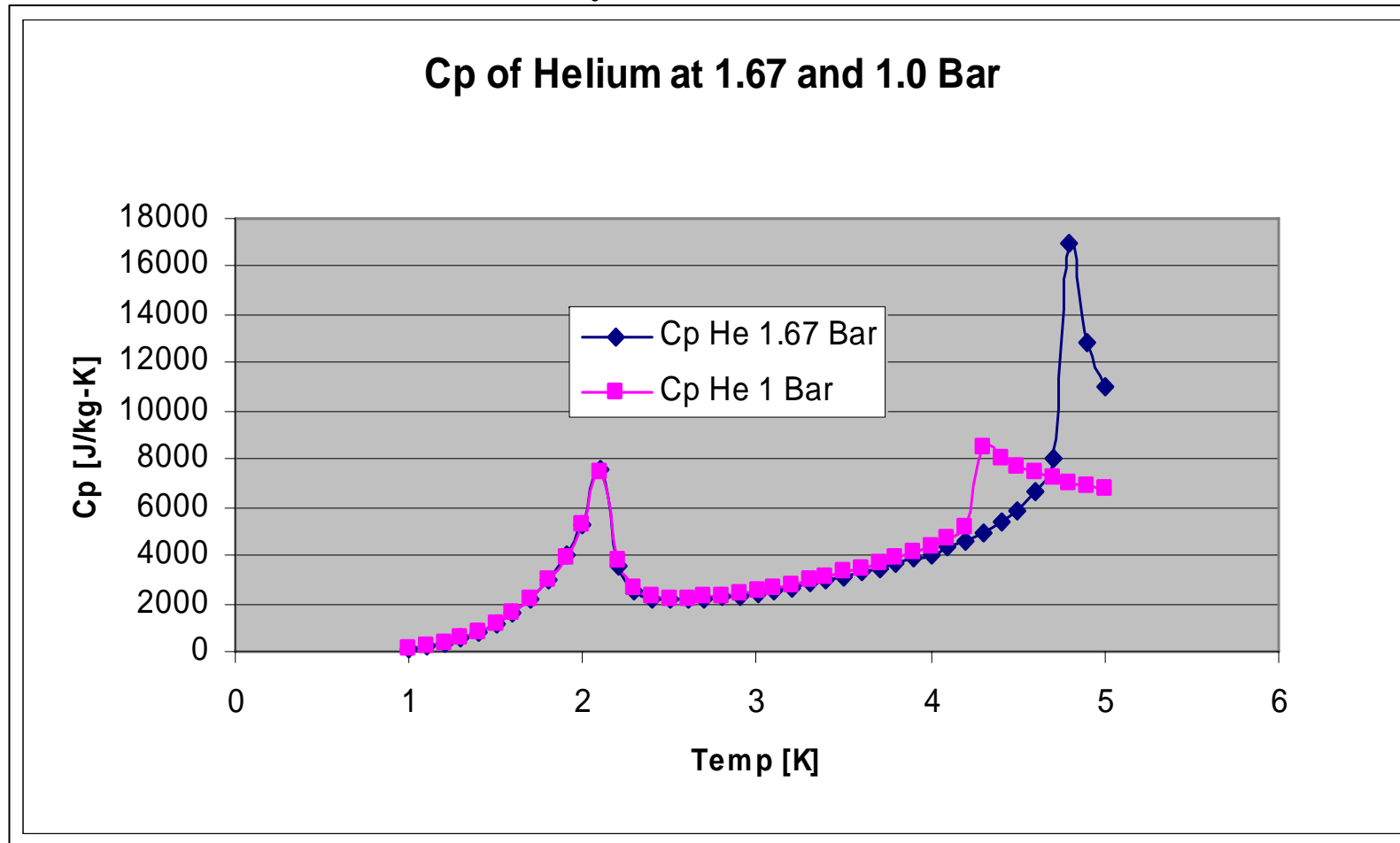
$$Nu = 0.259 Re^{0.8} Pr^{0.4} \left( \frac{\theta_w}{\theta_b} \right)^{-0.716}$$

Van Sciver,  
"Helium Cryogenics", pp. 143 - 144

$$\Delta T = \frac{q^3 L}{1200}$$



# HePAC



Old Dos Program that give Helium many properties.

BUT needed updating to new system before Dos disappears or changes !

[\\Srv2\\_div\cryo\TOOLS\CRYODATA\HEPAK3.4](\\Srv2_div\cryo\TOOLS\CRYODATA\HEPAK3.4)

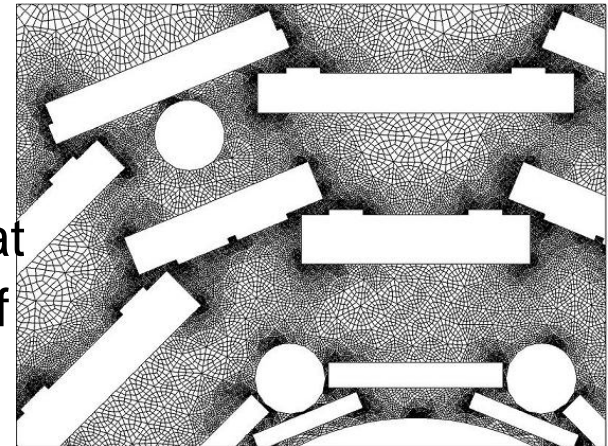
# Computational Fluid Dynamics

TS/CV/Detector Cooling - CFD Team



- ✓ Computational Fluid Dynamics (CFD) is an analysis of **fluid flow**, **heat transfer** and associated phenomena in physical systems using numerical methods.

- ✓ The basis of computational fluid dynamics is the reduction of the continuum differential equations describing the dynamics of the fluid (**Navier-Stokes + mass and energy conservation equations**) into a system of algebraic equations at a finite number of "grid" points, and the solving of the equations at these limited number of points only.



# A wide range of application fields

Aerospace

Automotive

Biomedical

Buildings

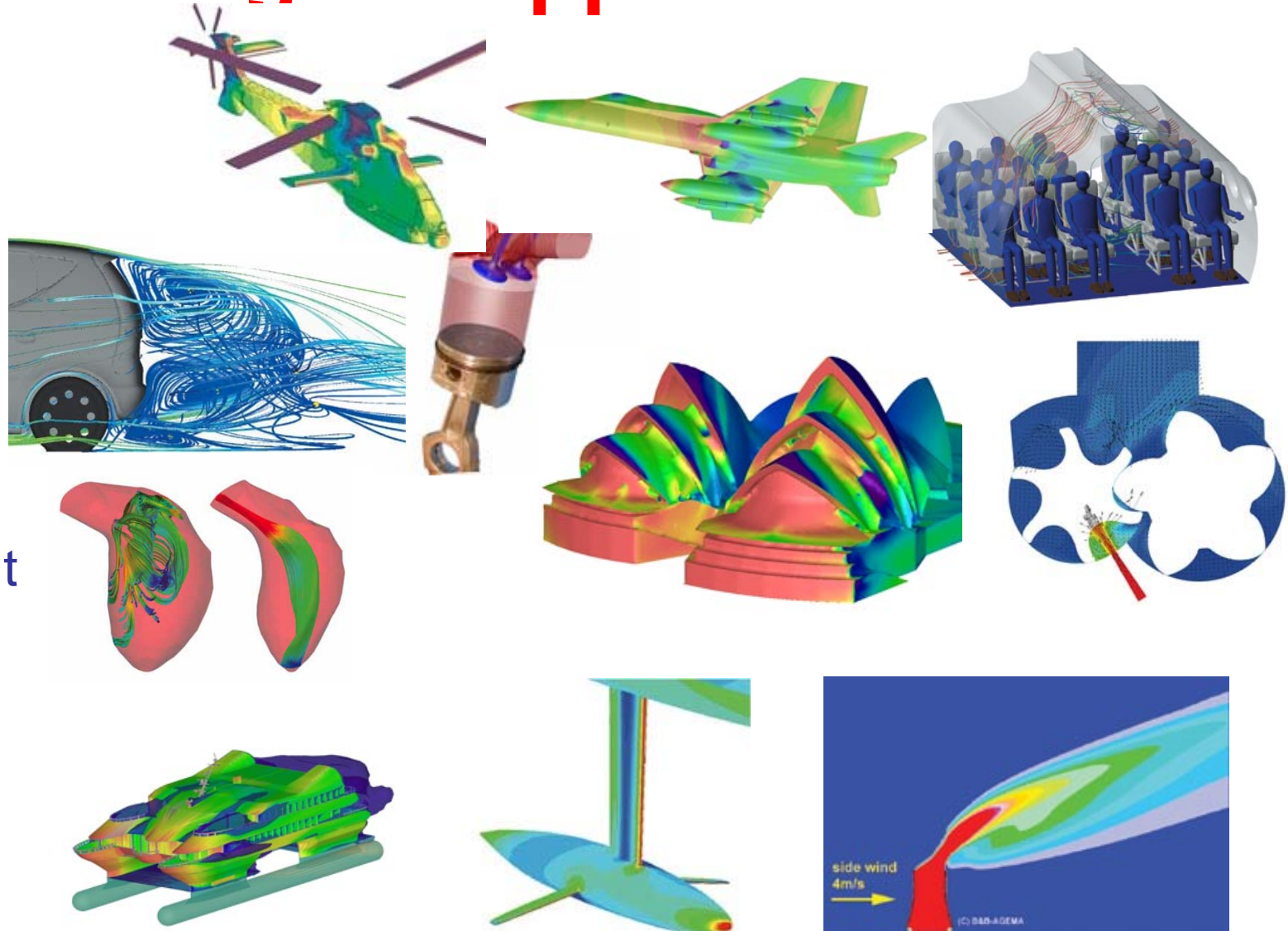
Chemical

Environment

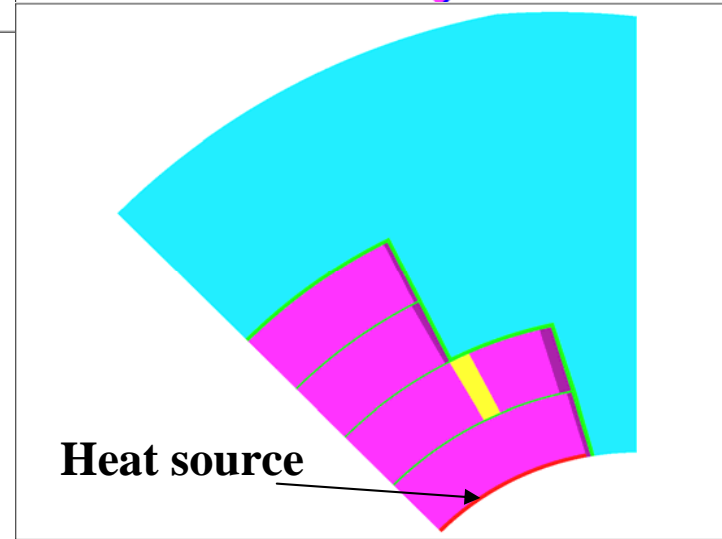
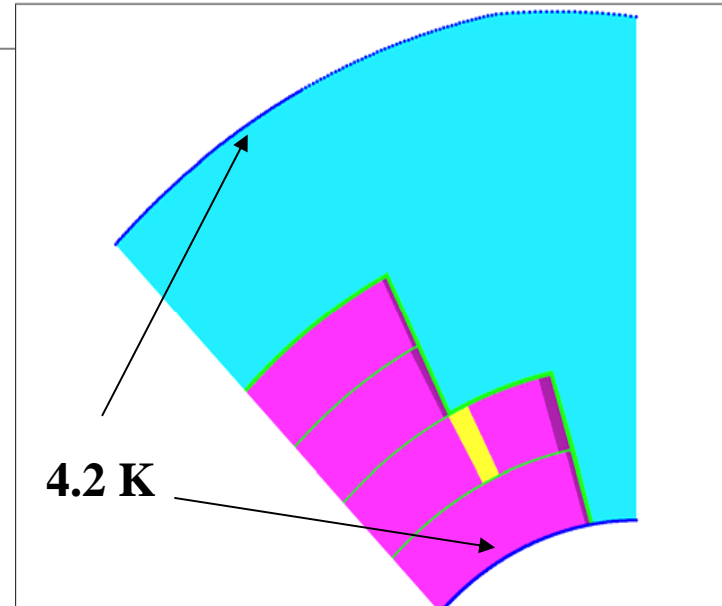
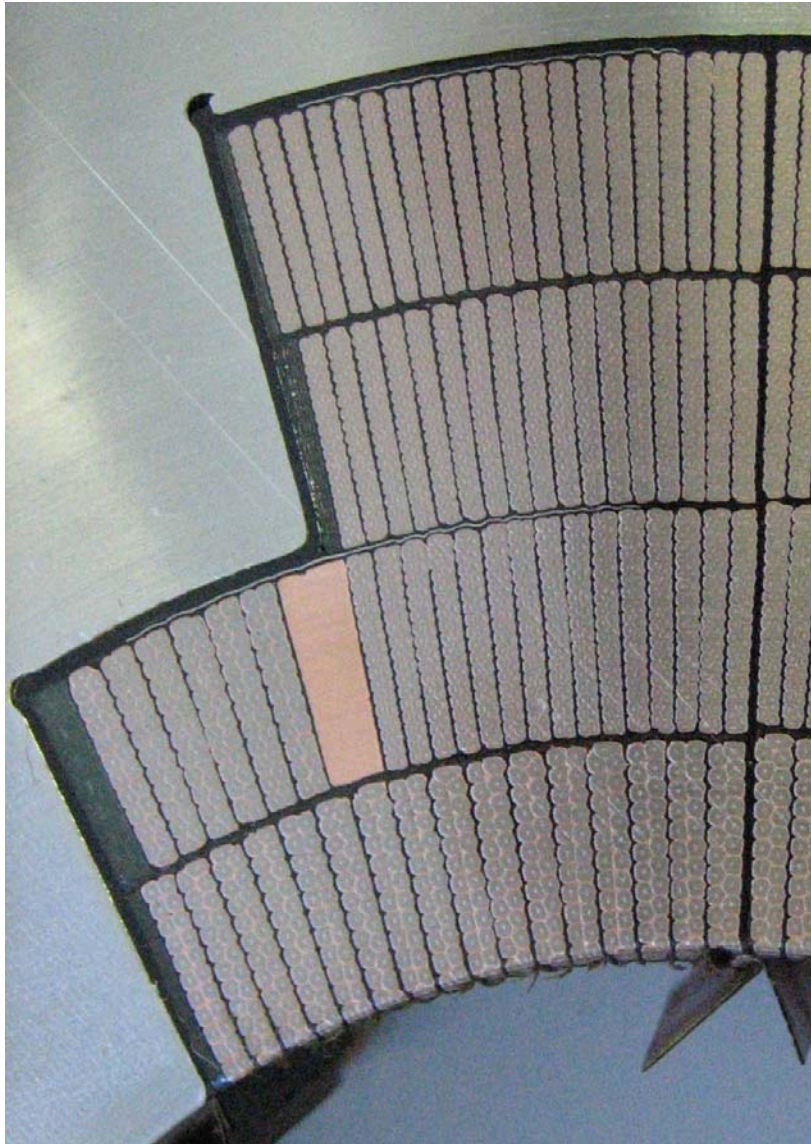
Marine

Power gen.

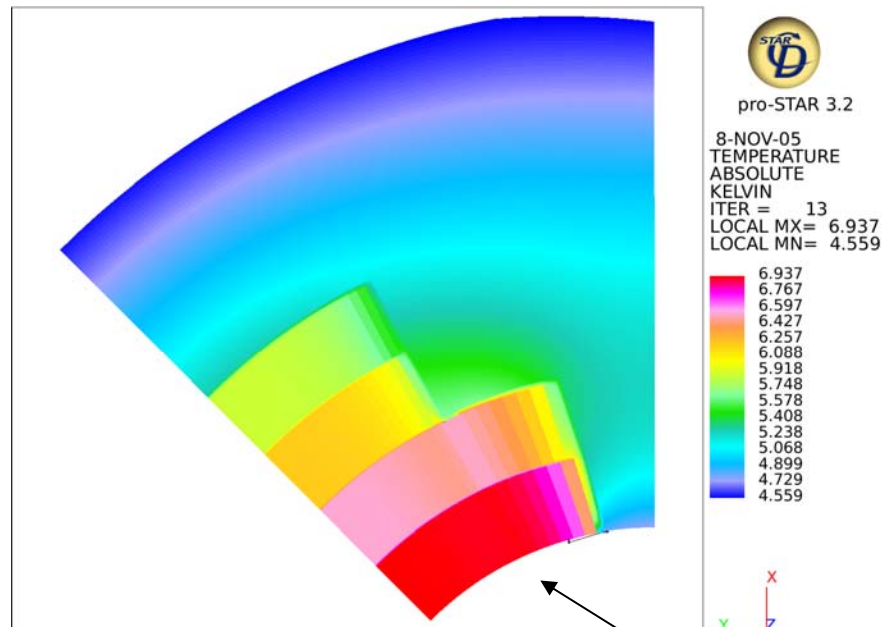
Turbo-  
machinery



# MQY study. Heat Conduction through coil with a simple annular heating at inner radii.

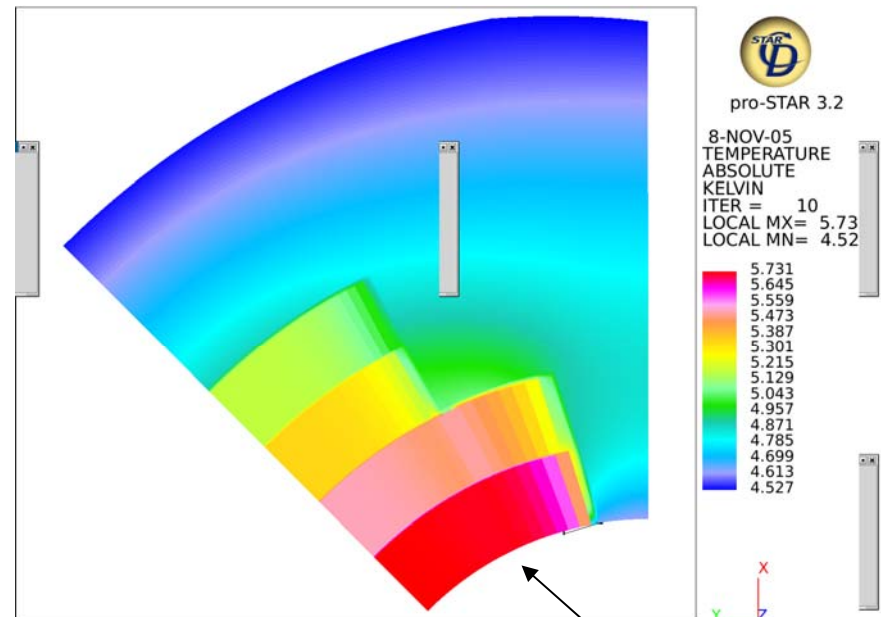


# Conduction heat distribution results



6.9 K

Heating 100 mW/cm<sup>3</sup>  
Into 2mm annulus

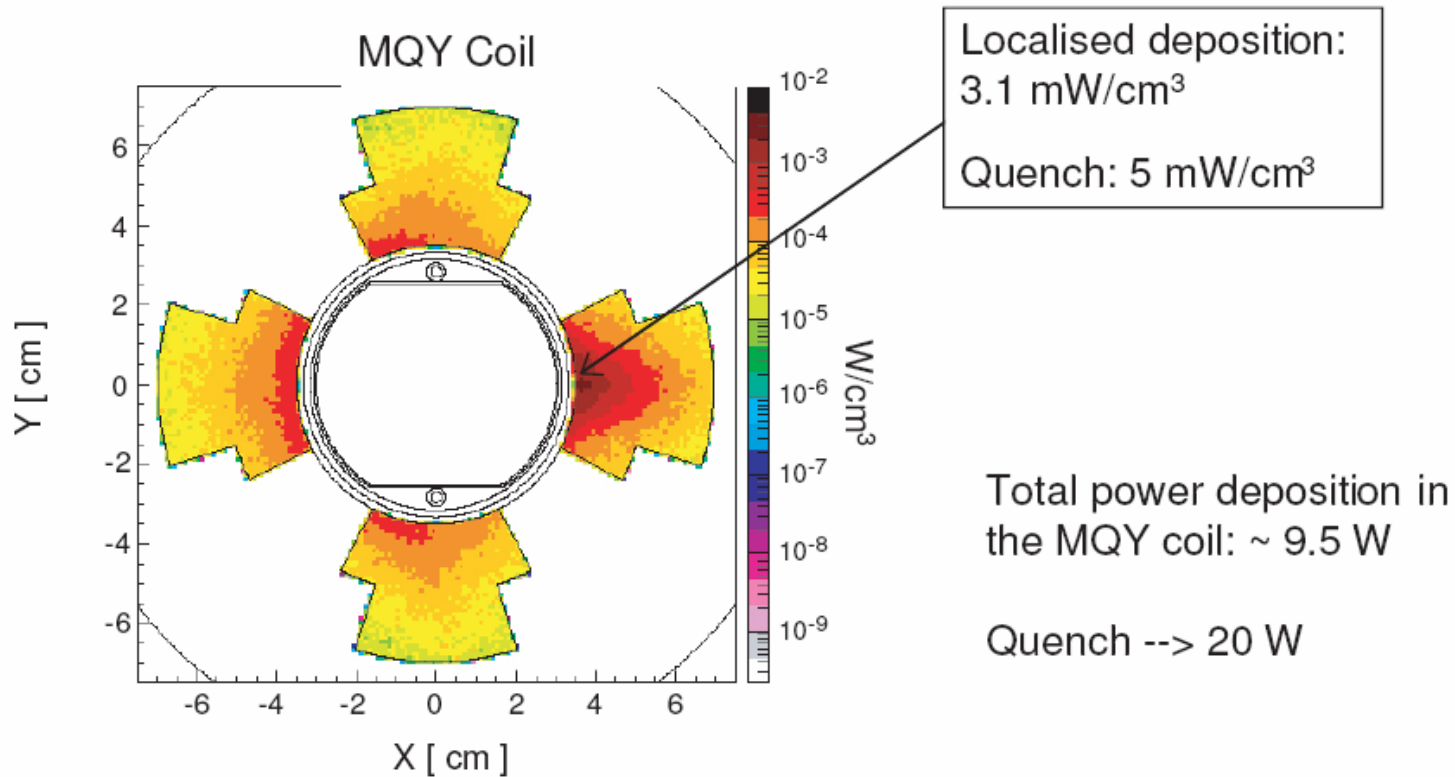


5.7 K

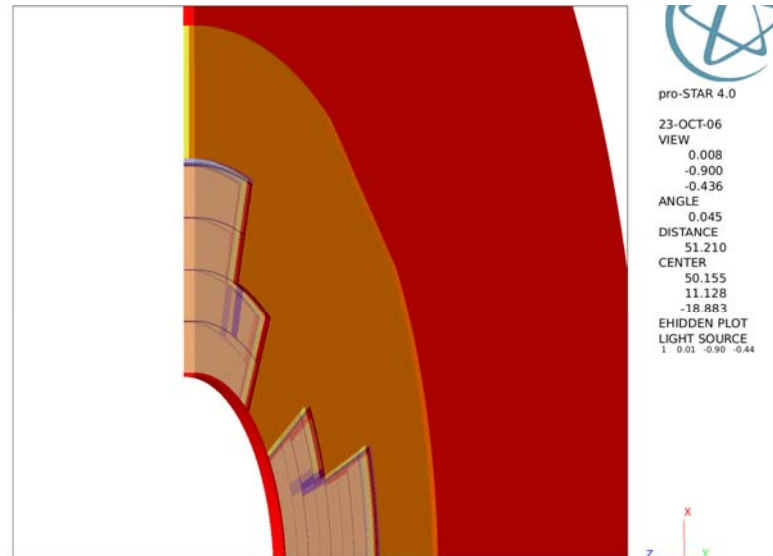
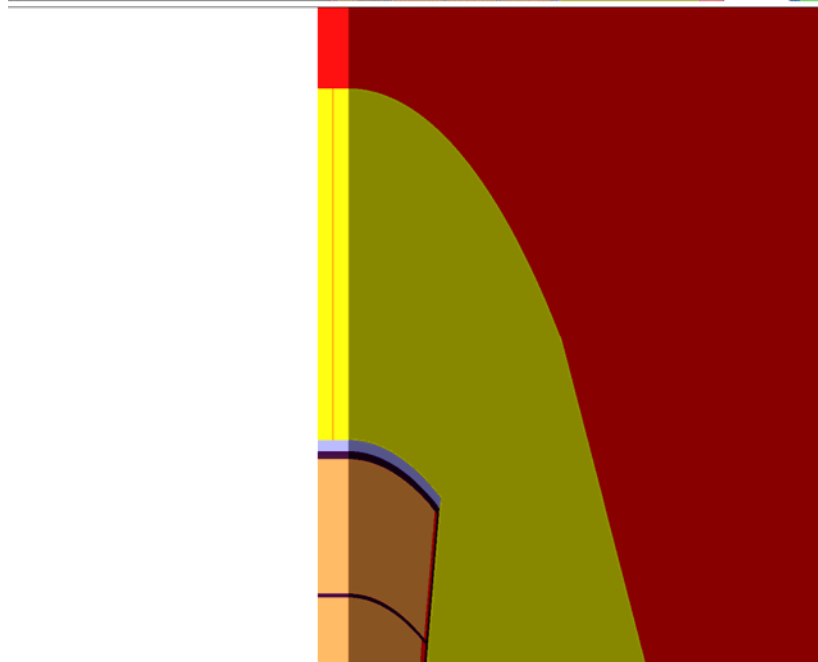
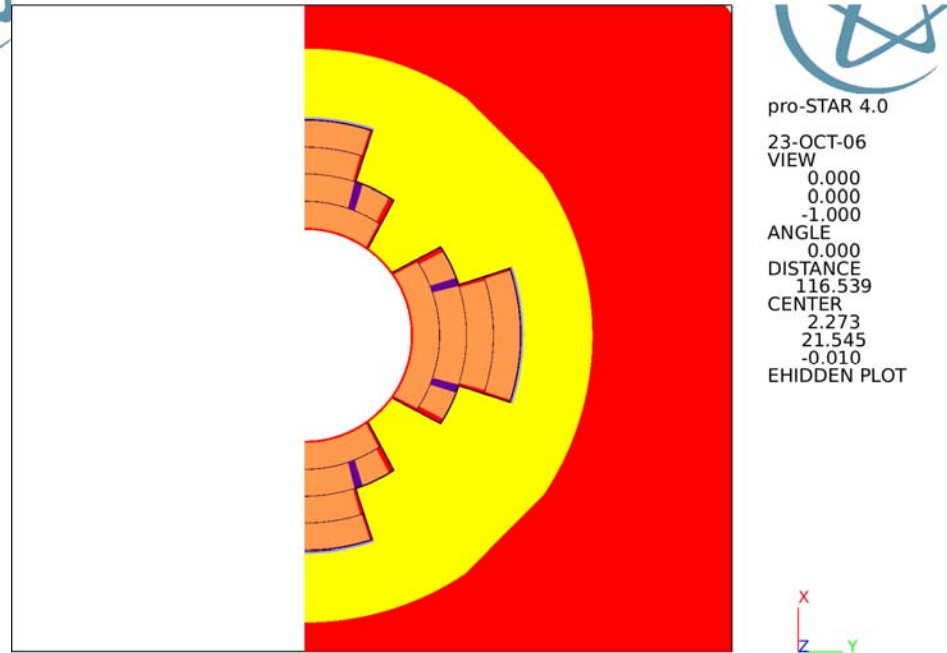
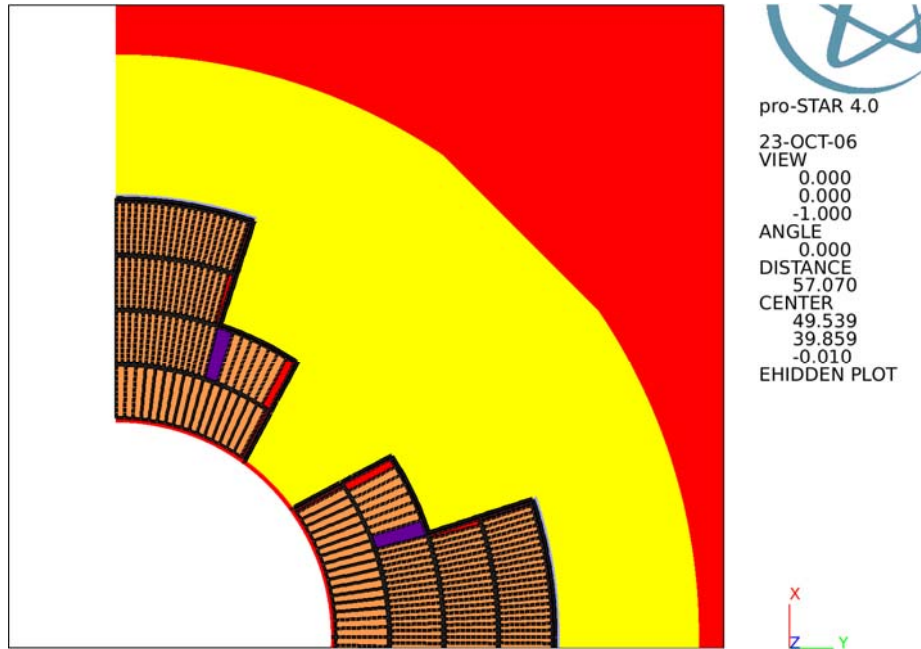
Heating 50 mW/mm<sup>3</sup>  
Into 2mm annulus



# Heat load

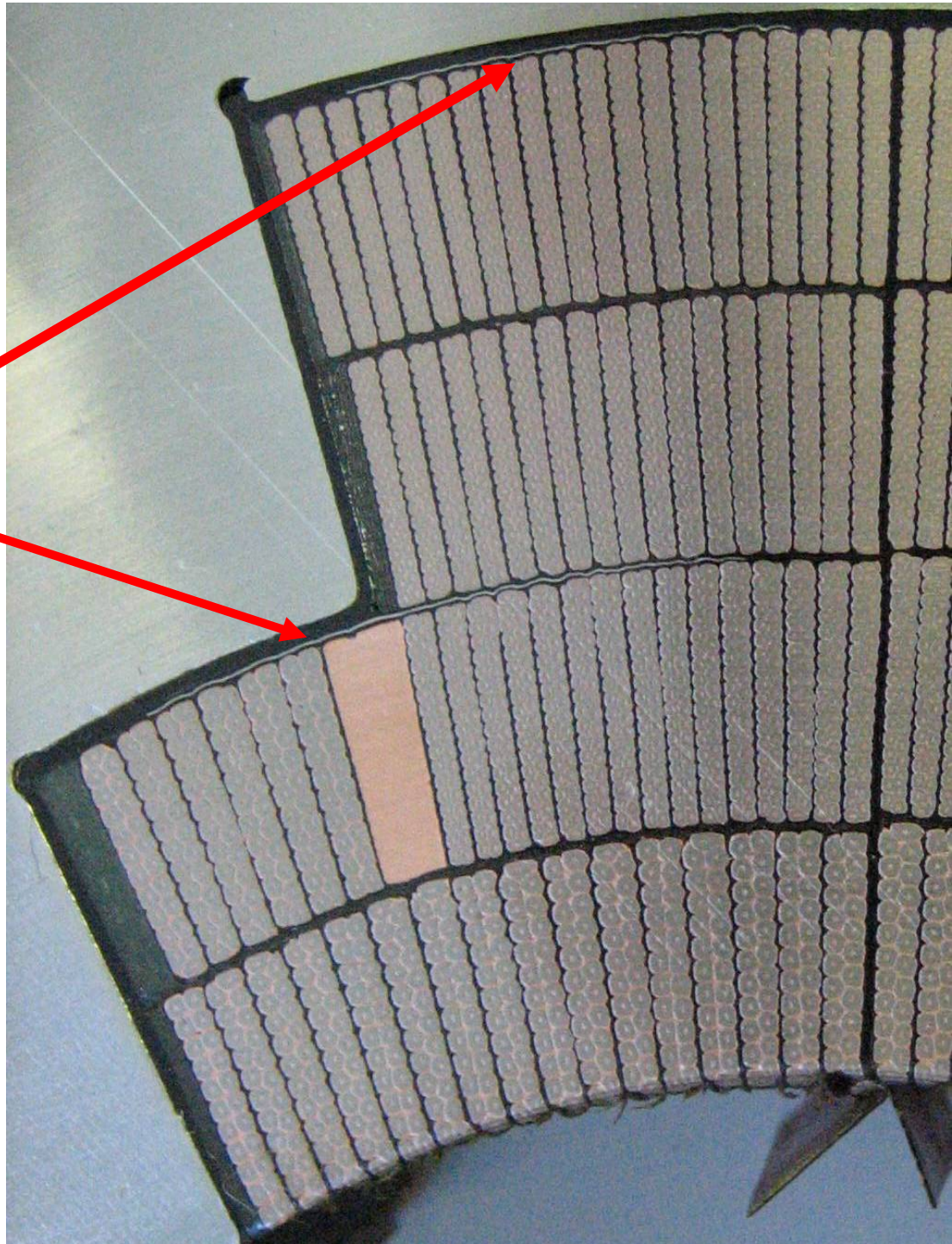


# Convection heat transfer through MQY at 4.5K



# Future tests

Quench heaters



The end

